A DESCRIPTION OF ATLANTIC MACKEREL, *SCOMBER SCOMBRUS*, EGGS AND EARLY LARVAE

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ABSTRACT

The development of laboratory-reared Atlantic mackerel, *Scomber scombrus*, eggs and early larvae is described in order to augment published descriptions of this species. The eggs are spherical, have a diameter of 1.01 to 1.28 mm, and have a single, yellowish oil globule, 0.22 to 0.38 mm in diameter. Melanophores, first visible after blastopore closure, assume a distinct pattern on the embryo. Melanophores are present on the oil globule but are absent from the yolk surface except immediately prior to hatching. Hatching occurs at 90 to 102 h after fertilization at an average incubation temperature of 13.8°C. Bodily pigmentation of the larvae undergoes considerable change during yolk absorption; eye pigmentation is apparent at 66 h after hatching. The yolk is fully absorbed by 137 h after hatching, and teeth are present in 192-h-old larvae.

To complement ichthyoplankton survey work underway at the Sandy Hook Laboratory, eggs of a few fish species have been artificially spawned and reared in the laboratory. These series of known identities were obtained for comparison with eggs and larvae from plankton samples. The purpose of this paper is to present descriptive information on the eggs and early larvae of Atlantic mackerel, *Scomber scombrus* Linnaeus 1758, and, in so doing, to augment previous descriptions of the young stages of this species, particularly of the eggs.

Previous publications containing helpful information on identification of North American Atlantic mackerel eggs and larvae are by Sette (1943), who included descriptive notes on eggs and larvae and compared them with young stages of other species present in the same waters, and by Bigelow and Schroeder (1953), who presented a brief egg and larval description and illustrated four larval stages. Other, less helpful, descriptive notes on North American Atlantic mackerel eggs and larvae are by Moore (1899), Dannevig (1919), Bigelow and Welsh (1925), Sparks (1929), Merriman and Sclar (1952), Wheatland (1956), and Marak and Colton (1961). Worley (1933) described the rate of embryonic development of Atlantic mackerel at various temperatures. Other papers describing eggs and larvae of Atlantic mackerel, probably of a separate European race (Garstang 1897-99), include Cunningham (1891-92a, b), Ehrenbaum (1905-09), Bigelow and Welsh (1925), Sella and Ciacchi (1925), and Padoa (1956). However, adequate descriptions of Atlantic mackerel eggs are lacking in the literature because descriptive information by most of the above authors is limited to reports of egg and oil globule diameters. Illustrations, where presented, are of little use in differentiating this from other species. The reported egg dimensions vary greatly and overlap those of other species present at the same time and in some of the same areas as Atlantic mackerel. Regarding this problem, Sette (1943) described a technique of plotting oil globule diameter against egg diameter for all eggs in hauls containing troublesome mixtures. In these scatter diagrams the Atlantic mackerel eggs remained discrete from other species' eggs.

The congeneric chub mackerel, *Pneumatophorus diego* (= *Scomber japonicus*) eggs and larvae from the eastern Pacific Ocean were described by Fry (1936), Orton (1953), and Kramer (1960) and from the western Pacific Ocean by Uchida et al. (1958), Dekhnik (1959), and Watanabe (1970). The papers by Orton, Kramer, and Watanabe contain very detailed and useful descriptions. Eggs and yolk-sac larvae of *S. scombrus* and *S. japonicus*, judged by my specimens and the above-mentioned descriptions, are similar, but differ in that: *S. japonicus* late-stage eggs and early yolk-sac lar-

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vae have more melanophores on the yolk surface than *S. scombrus*; and *S. scombrus* larvae, during and at the end of yolk absorption have several dorsal trunk melanophores, whereas few *S. japonicus* at this stage have any such pigmentation. In those *S. japonicus* which have dorsal melanophores on the trunk, it is apparently limited to a single patch near the 23rd myomere (Fry 1936; Uchida et al. 1958; Kramer 1960). Separation of the two species of *Scomber* early-stage eggs, before blastopore closure, may be impossible on the basis of morphological characters. Other factors, such as spawning time and area, and the proximity of older, identifiable stages, may be necessary for subjective identifications.

PROCEDURES

Running ripe Atlantic mackerel were caught by hook and line off Fire Island, Long Island, N.Y., during the morning of 2 June 1967. Several hundred eggs were stripped from one female and fertilized in a liter jar containing a small amount of seawater. The water was renewed about 20 min after introduction of the eggs and sperm, and the jar placed in a water bath to minimize temperature changes. The water temperature generally increased during egg incubation and larval life and ranged from 12.1° to 14.4°C for eggs and from 14.1° to 15.2°C for larvae (Table 1). Larvae were not fed and none survived longer than 8 days past hatching. Samples of the developing eggs and larvae were removed at intervals and preserved in dilute Formalin.[2]

While the following descriptions of eggs were based mainly on cultured eggs, planktonic eggs were utilized in obtaining dimensions (Table 2) and in confirming pigmentation, which tended to be faded and obscure in the cultured specimens. Owing to the internally damaged condition of early-stage eggs from plankton samples only middle- and late-stage eggs from that source were used for the above purposes. In the early-stage eggs the yolk and oil globule membranes ruptured and allowed the yolk and fractured oil globule to mix with perivitelline fluid. Planktonic eggs were taken by Gulf V high-speed samplers, with 0.4-m mouth and 0.52-mm mesh openings.

[2]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

TABLE 1.—Dimensions of Atlantic mackerel larvae, cultured series.

Hours from hatching	Number of larvae	Culture temp. (°C)	Standard length (mm)		Total length (mm)	
			Mean	Range	Mean	Range
0	3	14.1	3.25	3.03-3.36	3.39	3.16-3.50
6	10	14.1	3.47	3.30-3.58	3.62	3.47-3.75
18	7	14.1	3.59	3.44-3.70	3.76	3.61-3.84
42	8	14.4	3.77	3.67-3.84	3.99	3.89-4.05
66	3	14.6	3.85	3.78-3.94	4.08	4.00-4.16
137	7	15.2	3.92	3.84-4.03	4.14	4.05-4.19
166	3	15.1	4.02	3.81-4.25	4.24	4.03-4.47
192	2	14.8	3.97	3.75-4.19	4.21	3.97-4.45

The samples were taken in step-oblique tows at depths between 0 and 33 m, at a speed of 5.0 knots.

DESCRIPTION OF THE EGG

Dimensions

Formalin-preserved Atlantic mackerel eggs are spherical and have clear and unsculptured shells (Figure 1). The mean diameter of eggs from plankton samples is 1.13 mm (range 1.01 to 1.28 mm) and of those that were cultured is 1.20 mm (range 1.13 to 1.25 mm, Table 2). The cultured eggs were stripped from a single female, while those from plankton samples undoubtedly were spawned by many. This may account for the smaller range in egg diameter from the cultured series and the difference in mean diameters from the two sources. Differential shrinkage of egg diameter, due to varying time in preservation, between cultured and planktonic eggs is assumed negligible, as all eggs were measured more than a year after preservation.

The egg contains a single oil globule which is generally spherical and yellow or pale amber. Its diameter ranges from 0.22 to 0.38 mm, with a mean for all samples of 0.29 mm (Table 2). In many of our preserved samples, from both the cultured and planktonic eggs, the oil globules were fractured or distorted. The dimensions presented here lie within the range of those given by previous authors who have studied Atlantic mackerel. Published observations on eggs of this species from western North Atlantic waters report a range in egg diameter of 0.88 to 1.38 mm, with mean or modal values of 1.15 to 1.30 mm, and an oil globule diameter of 0.24 to 0.32 mm (Moore 1899; Dannevig 1919; Bigelow and Welsh 1925; Sparks 1929; Sette 1943; Merriman and Sclar 1952; Wheatland 1956; Marak and Colton 1961).

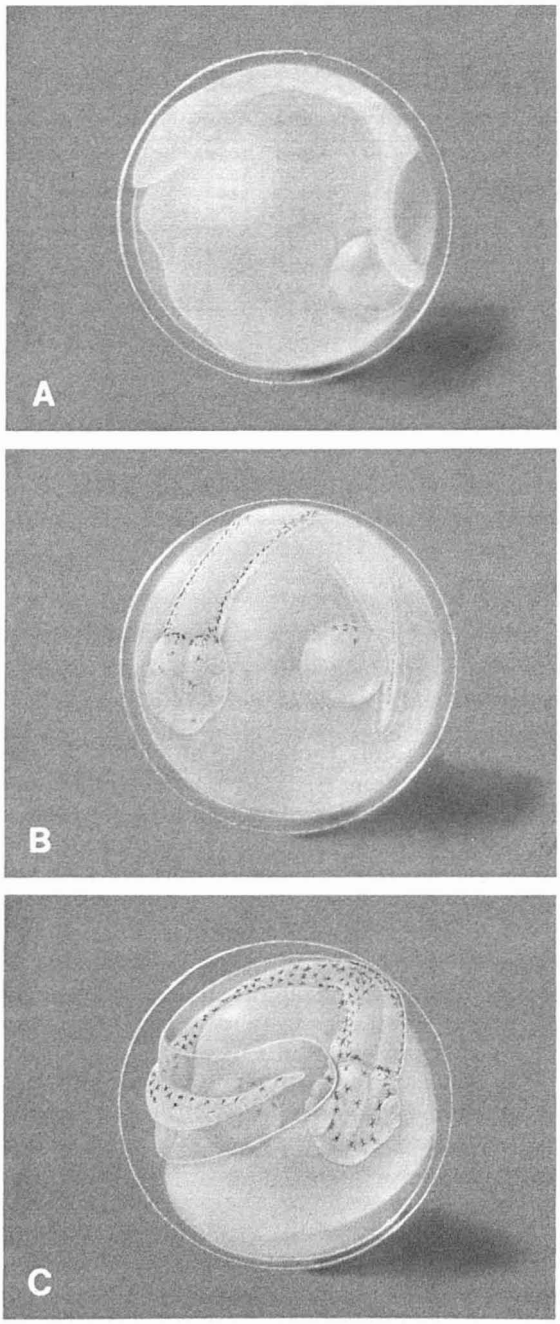

FIGURE 1.—Atlantic mackerel eggs: A, early stages; B, middle stage; C, late stage.

Perivitelline Space

In live eggs, the perivitelline space occupies about one-twentieth of the eggshell diameter, or about 0.05 mm. The eggs illustrated (Figure 1) are idealized only to the extent that the width of perivitelline space conforms to the observations on live eggs.

Pigmentation

Two large yellow chromatophores were observed in the live eggs at 60 and 85 h after fertilization. These chromatophores were situated on either side of the embryo immediately behind the head. No further notes on chromatophores of this color were kept. By the time I observed the eggs and larvae, several months after preservation, only melanophores were observed. All further comments on pigmentation refer to melanophores.

Development

Following the criteria of Ahlstrom and Ball (1954), this paper describes the development of the Atlantic mackerel egg in three stages: early (fertilization to closure of the blastopore), middle (blastopore closure to the twisting of the tail), and late (tail twisting to hatching). The early stage terminated shortly after 36 h, as the blastopore was 0.3 mm across at that time; the middle stage was completed by 72 h, when the tail was observed twisted; and the late stage lasted till hatching, by 102 h after fertilization. Incubation temperature ranges of the three stages were: early, 12.1° to 14.4°C; middle, 13.8° to 14.2°C; and late, 14.1° to 14.2°C.

Early-Stage Eggs (Figure 1A)

Early-stage Atlantic mackerel eggs are characterized by the dimensions given above and by the presence of a single yellow oil globule. The oil globule is off-center at the vegetal pole, opposite the blastodisc at first and, with development of the embryo, slightly posterior to the tail at the time of blastopore closure. There are no visible myomeres, pigmentation, or formed eyes.

Middle-Stage Eggs (Figure 1B)

Soon after the blastopore closes, pigmentation becomes visible on the embryo as numerous, scattered fine points on the dorsal surface of the thoracic region and a few back along the trunk.

TABLE 2.—Dimensions of Atlantic mackerel eggs from the cultured series and plankton samples taken during May and June 1966.

Item	Egg diameter (mm)			Oil globule diameter (mm)		
	No.[1]	Mean	Range	No.[1]	Mean	Range
Cultured series:						
Early stage	537	1.19	1.13-1.25	371	0.29	0.24-0.36
Middle stage	43	1.20	1.17-1.24	36	0.32	0.27-0.36
Late stage	42	1.20	1.16-1.22	42	0.32	0.28-0.33
Total cultured	622	1.20	1.13-1.25	449	0.30	0.24-0.36
Plankton samples, middle- and late-stage eggs:						
19 May 1966						
38°01.5'N, 74°59.0'W	54	1.18	1.06-1.28	53	0.32	0.27-0.38
17 June 1966						
41°17.0'N, 70°48.0'W	163	1.14	1.01-1.27	156	0.28	0.22-0.35
41°12.0'N, 70°47.0'W	114	1.12	1.02-1.26	113	0.31	0.24-0.38
41°07'N, 70°46.0'W	62	1.08	1.02-1.21	62	0.28	0.22-0.32
Total plankton	393	1.13	1.01-1.28	384	0.29	0.22-0.38

[1]Discrepancies between numbers of specimens in these columns are due to fractured or distorted oil globules, which were not measured.

As development progresses, these pigment cells become more intense and increase in number on the trunk where they tend to line up in two dorsolateral rows. The lateral melanophores in the thoracic region become dendritic and dense, while the middorsal melanophores fade. This distinct thoracic pattern persists until hatching. Melanophores appear on the anterior surface of the oil globule at the same time as those on the embryo.

The width of the head increases to almost twice that of the tail. The embryo increases in length, growing past the oil globule and encircling three-fourths of the egg by the end of this stage. The tail twists and flexes near the oil globule until it lies flat against the yolk surface. A finfold begins to develop on the posterior one-third of the embryo. Optic vesicles become prominent and up to six myomeres are discernible.

Late-Stage Eggs (Figure 1C)

At the start of the late stage, there are two dorsolateral rows of melanophores extending back from just behind the brain, well past the oil globule; there are few melanophores below these rows on the flanks. There is always pigment on the anterior half of the oil globule, and usually some on the snout and in a row behind the eyes across the head. During this stage, trunk melanophores migrate; they become scattered on the flanks and in some specimens a few melanophores posterior to the oil globule nearly reach the ventral edge of the body by the time of hatching. Pigment is lacking on the extreme caudal portion of the body. Melanophores on the oil globule darken and increase in number and coverage, so that just before hatching they are scattered over most of the oil globule. As many as 24 myomeres are visible prior to hatching. The dorsal line of melanophores behind the eyes persists on most embryos. The eyes are unpigmented through hatching.

The embryo increases in length until it encircles the yolk, with the tail overlapping the head just before hatching. The oil globule lies midway along the body, at the posterior end of the yolk sac, at hatching. The finfold deepens and extends forward to occupy the posterior two-thirds of the embryo. Before hatching the alimentary tract is visible posterior to the oil globule and terminates at the edge of the ventral finfold.

DESCRIPTION OF LARVAE

Rate of Development

Hatching occurred between 90 and 102 h after fertilization at an average incubation temperature of 13.8°C (range 12.1° to 14.4°C). This was a slightly faster rate of development than that reported by Worley (1933). At this temperature (13.8°C), interpolation of Worley's data would indicate a time to hatching of about 120 h. The yolk-sac stage ended by 137 h, for the yolk in all specimens was absorbed by that time.

Pigmentation at Hatching (Figure 2A)

Melanophores are distributed as follows: some tend to be in dorsolateral rows, extending on each side from the snout over the eyes to about nine-tenths of the body length, while others are

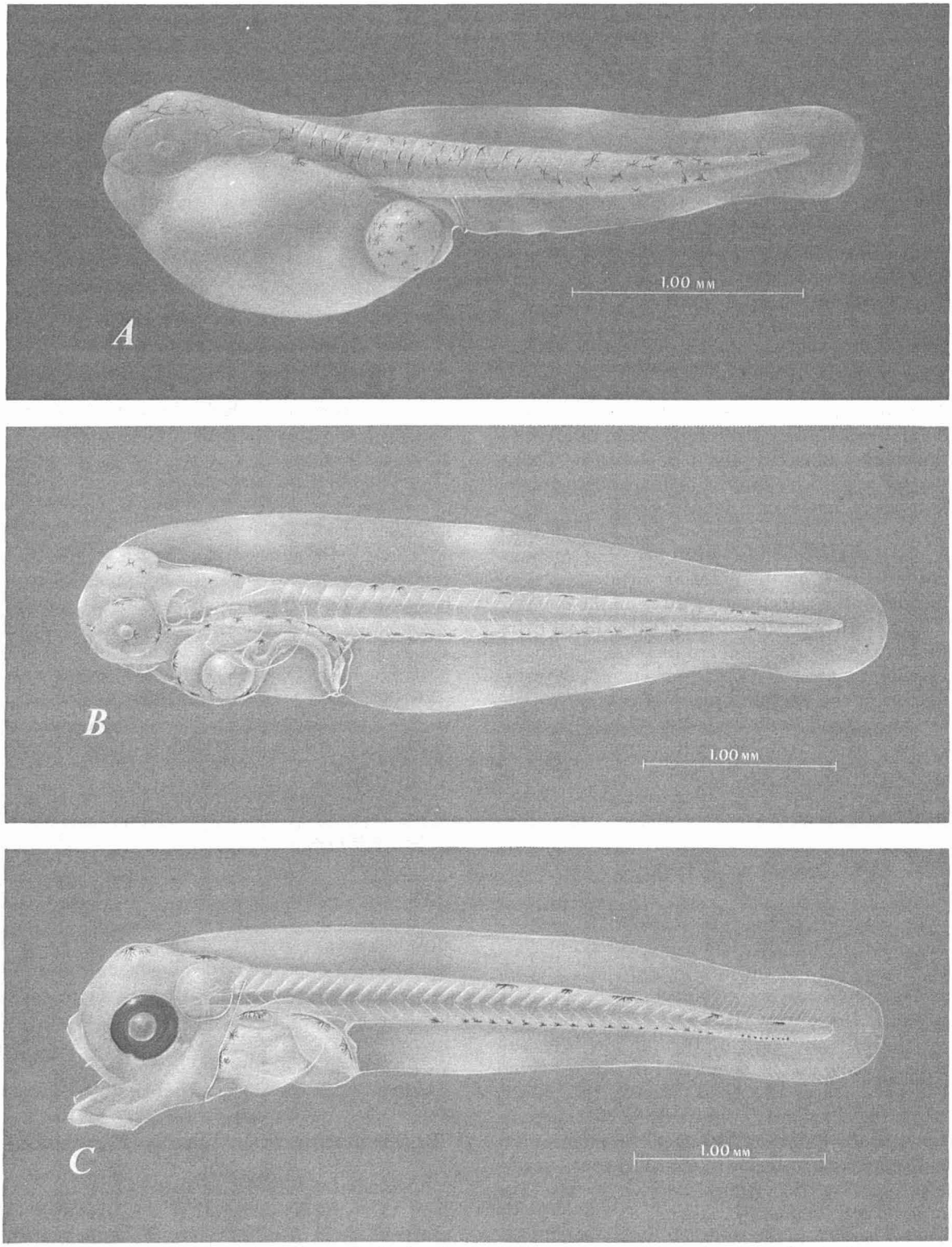

FIGURE 2.—Atlantic mackerel larvae: A, shortly after hatching; B, 66 h after hatching; C, 192 h after hatching.

scattered on the flanks; they are found on the nape; one on each side of the yolk-sac close to the otocysts; and scattered on the oil globule.

Subsequent yolk-sac stages undergo marked pigmentation changes, including the migration and formation, or initial appearance of melanophores. Orton (1953) reported similar melanophore migration in *Pneumatophorus japonicus diego* (= *S. japonicus*) eggs and yolk-sac larvae.

Head Pigmentation

Pigment on the head becomes reduced to a few melanophores dorsal to the eyes and on the nape (Figure 2B, C). At 66 h, pigment forms in the eyes. Some specimens, between 137 and 192 h, have a melanophore on the ventral midline between the developing dentaries where the basihyal forms.

Abdominal Pigmentation

Melanophores present on the oil globule at hatching and at 6 h start migrating to the ventral surface of the yolk sac by 18 h, and are mostly on that surface by 42 h. Subsequently, these melanophores tend to coalesce on two areas: on the forward end of the gut cavity between the cleithra (Figure 2B, C) and, in some specimens, on the ventral surface of the hindgut. This pigmented area on the hindgut varies in occurrence, intensity, and location.

At 18 h, some of the melanophores which were on the sides of newly hatched larvae, above the middle of the yolk sac, are migrating ventrally and inward above the yolk mass. By 66 h, this pigment is situated over the dorsum of the midgut and hindgut. Older specimens, up to 192 h, all have intense or large dendritic melanophores directly above the gut cavity (Figure 2C).

Caudal Pigmentation

The two dorsolateral rows of melanophores, already somewhat scattered on the flanks at hatching (Figure 2A), migrate toward the bases of the dorsal and anal finfolds; this condition is complete by 66 h (Figure 2B). Those melanophores at the dorsal finfold base decrease to about 6 by 192 h and are located on the posterior half of the larva; those in the ventral row increase to about 20 to 25 and extend from near the vent back to the caudal extremity, exclusive of finfold.

Myomeres

At 102 h, only 23 or 24 myomeres were observed in the unhatched eggs. Others most certainly present were obscured by the opacity of the yolk. In the newly hatched larvae, however, the full complement of 31 myomeres was evident.

Finfold

In newly hatched larvae, a continuous finfold extends posteriorly on the dorsal surface from slightly behind the auditory vesicle, around the caudal extreme, then forward on the ventral surface to the yolk sac. The finfold broadens, lengthens, and reaches the top of the head by 66 h where it persists to 192 h. With development, the ventral finfold extends forward to the anus, and as the yolk sac decreases in length the preanal finfold occupies the area between the anus and yolk sac. Actinotrichia are barely visible in the caudal portion of the finfold on newly hatched larvae and become more evident on older stages (Figure 2).

Alimentary Canal

The hindgut, observable in the ventral finfold of larvae at hatching as a narrow tract, is much thickened at 18 h. Mouth rudiments are present on 66-h larvae, and by 137 h, when the yolk material is completely absorbed, the mouth is open. A pair of recurved teeth occur on each jaw at 192 h (Figure 2C).

Otocysts

The otocysts are visible at hatching. Developing otoliths are barely visible at 42 h and are plainly evident by 66 h (Figure 2).

Pectoral Buds

The newly hatched larvae have pectoral buds. By 66 h, these buds have fleshy bases, fan-shape membranes, and appear functional (Figure 2A, B).

SUMMARY

For identification purposes, it is useful to summarize some of the more prominent features of Atlantic mackerel eggs and early larvae. The

egg has an average diameter of 1.08 to 1.20 mm, and contains a single, yellowish oil globule averaging 0.28 to 0.32 mm in diameter. A distinctive pigment pattern forms on the embryo after the blastopore closes. The eyes remain unpigmented through hatching.

Pigmentation on the larvae undergoes considerable change during the yolk-sac stage. Newly hatched larvae have scattered melanophores on the dorsal and lateral surfaces of the head and trunk and on the oil globule. By the time the yolk is used up, pigment coalesces onto the dorsal and ventral surfaces of the trunk, above the brain and gut, and forms in the eyes. Teeth are present in 192-h-old larvae, at a size of 4.0 mm standard length.

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